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Mine Resistant Boots

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The task of demining is highly dangerous. Deminers and humanitarian workers are at risk to injury every time they step onto a minefield. Jiri Chladek and the Zeman Company have developed a special boot to reduce risks incurred when stepping on landmines.

by Jiri Chladek, M.Sc.,Dr., *Independent Advisor & Expert in Explosives*

Each war brings killing. To kill the enemy, machine guns, cannons, tanks… and also landmines can be used. When the war finishes, soldiers return home, tanks go away and only landmines—these small hidden killers remain. They are sleeping in the soil and waiting for their own victim. They are sleeping in the soil and waiting for 10, 20, 30 or 50 years. They are waiting on somebody's last step…

During the war killing is casual. It is terrible, but killing soldiers during the war is casual. Why do the landmines kill civilians, children or farmers 20, 30 or 50 years after the war? Why? Because there are over 100 million landmines scattered in 60 countries in the world. Therefore the Zeman Company started their own development of protective boots.

Already different technologies for mine and UXO locating exist and new methods and technologies are likely to be developed in the near and fast future. But during different demining operations, a deminer must walk across suspicious areas, as well as many humanitarian workers and all who remedy former battlefields. For all of these people we prepare "Blast Protective" or "Mine Resistant Boots."

Independent Development

Dr. Chladek's Independent Development

Dr. Chladek began work geared at solving the problem of foot protection in 1997. First, he collected different materials appropriate for amour construction and then prepared a number of different flexible armours. The armours differed in material, number and thickness of layers, and technology of layer connection.

Each sample was then tested by explosion. As testing charges were used, boosters were made from TNT, PETN and Semtex. In accordance with the results of previous steps, new test samples were obtained and a sole was made. After successful trials with different explosive charges, there appeared a clear request: co-operation with a boot producer is necessary. It was necessary to know which material and which technology can be used for resistant boots production.

ZEMAN Shoe Ltd.'s Independent Development

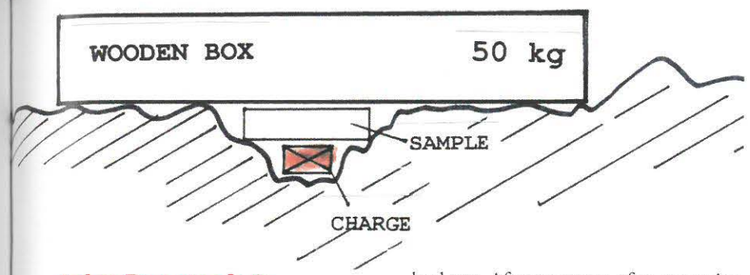
In 1998 Zeman Shoe Ltd. also started R & D work concerning mine resistant boots. During the preliminary stages they used available information from abroad and experience from tests carried out in the United States. Zeman Shoe Ltd. based their development on a sole with a special shape that contained an aluminum insert for moving explosion gases away from the boot.

A final prototype was prepared for tests in spring 1999. These tests showed that their direction in R & D blast resistant boots was not successful. The boots did not have the required protection level. During the tests they also obtained some interesting findings:

- Sole shape is not so important and it has minor effects on protection level.
- Boot construction must not contain any metallic parts.
- It is necessary to find appropriate testing methods (there are no international standards).

After the tests, the company found it necessary to find an expert experienced in explosives and explosive protection. Representatives of Zeman Shoe Ltd. met with Dr. Chladek, independent expert in explosives, at the exhibition IDET 99 and a new era in R & D of blast protective boots successfully began.

■ (Left to Right) Prototypes of armours prepared for testing. Steel leg second generation. Boots with steel leg second generation filled by silicone rubber.



■ Test position.

Joint Research & Development

Both sides first met during an International Exhibition of Defense Technology (IDET 99) in May 1999 in Brno, Czech Republic. At the start, they were given basic requirements for the final product:

- Boots should be appropriate for all-day wearing,
- Must be resistant against AP mines and/or unexploded ordnance like submunitions and related items containing at least 35g HE,
- Must be designed for all people who must walk across dangerous areas, especially the wide range of humanitarian workers as well as for de-miners.

During R & D work each material and technology was tested by explosions of different charges. It was necessary to find new technologies and also new materials appropriate for resistant boot production. Special attention was given to the main parts of the boots: sole, toecap and heel seat. After two years of co-operation new mine resistant boots were made.

Testing

The main problem concerning testing is the lack of international standards. During the preliminary period each sample was loaded by a wooden box filled with sand and soil with a total mass around 50 kg. Later a few different steel legs were used, but the results showed that these tests did not meet the R & D requirements. Useful results were obtained when "wooden man" (block of wood) with a mass of around 65 kg was used. Trials with charges exploded in front of the boots simulated a situation when the user kicks the unexploded ordnance. The boots were independently tested at the Institute for Testing and Certification of Boots (ITC). Tests results showed that the test boots meet the requirements of the CSN EN 344-1 and CSN EN 347-1 standards. Very optimistic results concerning a sole puncture resistance in value 2958 N (standard required min. 1100N) were also obtained. Details are available in Final Report No. 72330219/2001.

The final tests were undertaken in the testing facility of the Department of Theory and Technology of Explosives at the University in Pardubice. Tested boots were fitted to a measuring device of its own construction and equipped by an accelerometer. The weight of one person was simulated by a 65 kg weight situated into the basket.

During tests, researchers placed a testing charge under the heel in contact with the sole. The AP mines were simulated by a plastic ring, 45 mm in diameter, filled by 25, 35 or 50 g of plastic explosive Semtex. They also carried out tests using a charge buried two cm in the soil (*).

Result of Co-operation

The combined efforts of Jiri Chladek and Zeman Shoe Ltd. were able to intro-

Table I. Result of tests

SAMPLE	CHARGE	COMMENTS
Ordinary combat boots	25g	fatal destruction of boot and leg—AMPUTATION !
Zeman AM	25g	damaged heel
Zeman AM	35g	damaged heel and part of sole
Zeman AM	50g	heavily damaged heel, inner part of boot OK
Zeman AM	25g*	minor damage of heel

■ (Left to Right) Sample weighted by "wooden man." Boot and charge of Semtex prepare for test. Measuring equipment. Boot prepared for test.

■ Boots before explosion and after explosion.

duce a product called "Mine Resistant Boots," model Zeman AM (Anti-Mine) offering resistance against AP mine explosions and unexploded ordnance with a charge around 50g HE. The boots are characterized by a robust and resistant design with long-term service life. They do not contain any metallic parts.

Technical Specification and Description of Mine Resistant Boots

The "Mine Resistant Boots" model Zeman AM are a special all-leather boot with protection against explosion of AP contact mines and related UXO items with a charge around 50 g of high explosive. The boots can be provided with Sympatex lining, which ensures 100 percent waterproof protection while keeping comfort by letting perspiration out of the boot.

Boot Description:

- Upper material grain leather, hydrophobic, smooth, thickness of 2.0–2.2 mm
- Leather counter
- Double thermal toe puff
- Special lasting insole from ballistic material of the thickness of 7 mm
- Bottom design with use of sewn through technology
- Special rubber sole with the thickness of 20 mm combined with ballistic material while preserving sufficient flexibility
- Closed tongue
- Leather collar bandage
- Sock lining absorbing treading energy in toe
- Lacing: 4 eyelets 5 passes through
- Thread stitching 1000
- Black color
- Boot height: 30 cm
- Weight: only 2980 g per pair
- Sizes: 6–12

Protection

The Mine resistant (Blast Protective) boot model ZEMAN AM offers a few levels of protection.

1st Level—Multi-Layer Armour in Sole

The sole contains a special multilayer ballistic armour. When excessive pressure (energy of explosion) is exerted on the armour, part of the energy is reflected back from the armour, part is consumed by programmable destruction prepared layers, part flows around the boots to surrounding space and only a small part of the energy goes through the multilayer armour and hits the inner armour.

2nd Level—Inner Armour

The inner armour is situated inside the boots, around the lower leg. This reduces an effect of overpressure entering through the multi-layer armour (from sole) as well as overpressure and fragments incoming from the surrounding area. Special attention was given to the development of a heel seat and toe cup. Trials with charges exploded in front of the boots simulated a situation when a user kicks at unexploded ordnance. The human body received only a small part of the energy entering through the multilayer armour because the inner armour reduces it.

3rd Level—Ballistic Protection

All-leather parts of the boots are reinforced by ballistic material. It ensures ballistic protection against fragments (mine bodies, soil, stones) accelerated by explosion or other flying particles.

4th Level—Anti-Perforation Protection

Special construction of the sole ensures 250 percent anti-perforation according to the requirements of EU standards. It protects 2–5 times more than special safety shoes containing usually steel anti-perforation inserts.

5th Level—Tread Energy Protection

Special construction of heel and anatomic replaceable innersoles absorb tread energy in the heel seat. ■

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**All photos courtesy of the author.*

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■ Zeman AM—Blast Protective Boots.